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Department of Chemistry, M/C 111  
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Chicago, IL 60680

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Scanning Tunnelling Microscope for Boron Surface Studies

## 2. PERSONAL AUTHOR(S)

Michael Trenary

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The equipment purchased is to be used in an experimental study of the relationship between atomic structure and chemical reactivity for boron and carbon surfaces. This research is currently being supported by grant #AFOSR-88-0111. A renewal proposal is currently pending with AFOSR to continue these studies. Carbon and boron are exceptionally stable, covalently bonded solids with highly unique crystal structures. The specific reactions to be studied are loosely related to the problems of oxidation and oxidation inhibition of carbon/carbon composites. The main experimental instrument to be used is a scanning tunneling microscope (STM) purchased under grant number AFOSR-89-0146. Other techniques to be used include Auger electron spectroscopy, X-ray photoelectron spectroscopy (XPS), ultraviolet photoelectron spectroscopy (UPS), low energy electron diffraction (LEED), temperature programmed desorption (TPD) and scanning tunneling microscopy (STM).

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Final Report for DoD-URIP AFOSR-89-0146  
Scanning Tunnelling Microscope for Boron Surface Studies

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Summary of Research Projects using Equipment Purchased Under Grant

The equipment purchased is to be used in an experimental study of the relationship between atomic structure and chemical reactivity for boron and carbon surfaces. This research is currently being supported by grant # AFOSR-88-0111. A renewal proposal is currently pending with AFOSR to continue these studies. Carbon and boron are exceptionally stable, covalently bonded solids with highly unique crystal structures. The specific reactions to be studied are loosely related to the problems of oxidation and oxidation inhibition of carbon/carbon composites. The main experimental instrument to be used is a scanning tunneling microscope (STM) purchased under grant number AFOSR-89-0146. Other techniques to be used include Auger electron spectroscopy, X-ray photoelectron spectroscopy (XPS), ultraviolet photoelectron spectroscopy (UPS), low energy electron diffraction (LEED), temperature programmed desorption (TPD) and scanning tunneling microscopy (STM). Previous studies have indicated that the basal (0001) plane of graphite is relatively inert and that the reactivity is much higher at {1010} edge sites. It has been found empirically that  $B_2O_3$  inhibits the oxidation of carbon/carbon composites and it has been postulated that this is due to the blocking of reactive sites. We will use STM to obtain an atomic scale understanding of the interactions of  $O_2$  and  $B_2O_3$  with a graphite surface. We will also characterize the adsorption, desorption, and possible reactions of  $B_2O_3$  on graphite with TPD and XPS. For the boron surface work we will grow boron films by chemical vapor deposition on a Ta(110) surface. Such a procedure will allow us to follow the development of the structures of  $\alpha$  and  $\beta$  rhombohedral boron and correlate the observed structures with their chemical reactivities. The proposed experiments represent a continuation of our current work on the reactions of  $O_2$  and  $B_2O_3$  with a  $\beta$ -rhombohedral boron (111) surface.

Description of Equipment Purchased

This is the final report on equipment purchased with funds provided under the above grant. The original budget request was for \$72,000 from DoD with \$20,000 cost sharing from the University of Illinois at Chicago. The actual amount of the DoD award was \$49,000. A revised budget was submitted on Oct 27, 1988 for a total of \$84,000 of which \$35,000 was to be provided by university funds with \$49,000 provided by the DoDURIP grant. As stated in the revised budget, the \$84,000 was to be used to

purchase the STM made by W. A. Technology of Cambridge, England. This company is represented in the USA by Microscience, Inc., of Norwell, MA. The development of commercial STM's is occurring at a rapid pace. In the time interval between the submission of our revised budget and the time when sealed bid responses were received by the university, McAllister Technical Services, Inc. developed a UHV compatible STM which appeared to meet our specifications. The McAllister STM was also the least expensive available. The money saved by purchasing this STM was used for various other components needed for its successful operation in our UHV chamber. Specifically, we needed to design and build a new sample holder and heater as well as sample transfer system. This allows us to readily transfer a sample from the STM to our main manipulator. Although the sample can be heated to as high a temperature as desired with electron bombardment, the transferability currently precludes direct measurement with a thermocouple. Thus it was necessary to purchase an optical pyrometer for measuring the sample temperature. With the sample on the main manipulator, it can be characterized by other techniques which include low energy electron diffraction and X-ray photoelectron spectroscopy. The sample heating and transfer system for STM use has been thoroughly tested and debugged. It now works reliably and is currently being used.

<u>Item</u>	<u>Vendor</u>	<u>Price</u>
Scanning tunnelling microscope (STM) with control electronics and software	McAllister Technical Services (formerly of Berkeley, CA now in Coeur d'Alene, ID)	\$54,950
IBM 386 25 MHz computer, 80 MByte hard disk, 80387 coprocessor	McAllister Technical Services	\$4,784
Graphics and text monitors for SIM computer	Microage, Chicago, IL	\$650
Electrometer for independent measurement of STM current	Keithley Instruments Cleveland, OH	\$3,120
Oscilloscope for analyzing STM performance characteristics	Tektronix, Beaverton, OR	\$2,952
Power supply for STM sample heating	Sorenson, Chicago, IL	\$1,325

Vibrational isolation table for vacuum chamber (necessary for operating STM in ultra high vacuum)	Barry Control, Watertown, MA	\$6,800
Optical pyrometer for measuring STM sample temperature	Pyrometer Instrument Co., Northvale, NJ	\$2,330
Two spare piezo scanning tubes for STM	McAllister Technical Services	\$950
Miscellaneous parts for STM compatible sample holder, sample heater and sample transfer.		\$6,139
Total		\$84,000